THE JOURNAL

OF THE

ROYAL AERONAUTICAL SOCIETY

(FOUNDED 1897 in succession to the ANNUAL REPORTS)

Edited for the Council by J. LAURENCE PRITCHARD, Fellow

No. 167 NOVEMBER, 1924 VOL. XXVIII

NOTICES

Election of Members

The following Members were elected at a meeting of the Council held on October 21st:—

Associate Fellows.—Mr. J. D. Haddon and Mr. C. A. Pike.

Student.—Mr. J. C. Dodds.

Associate Fellowship Examination

The following is the list of successful candidates in the Society's examination for Associate Fellowship which took place on September 23rd:—Mr. E. C. Gibbons, Mr. C. A. Wright and Mr. G. Lyon.

R.38 Memorial Prize

Intending competitors for next year's prize are reminded that they should send their names to the Secretary on or before December 31st with such information as will enable arrangements to be made for their examination. The closing date for the receipt of papers will be March 31st, 1925.

Edward Busk Memorial Studentship

The Trustees of the Edward Busk Memorial Studentship in Aeronautics at Cambridge University have awarded the Studentship for the first year to Mr. J. C. Stevenson, Associate Member of the Scottish Branch.

Donations

The Council desire to thank Mr. Griffith Brewer for a gift of chairs for use in the Library during lectures, and Major J. H. Ledeboer, Dr. Hankin and Sir Mackenzie Chalmers for a number of back numbers of the Journal, many of which are now out of print.

Lantern Slides

Members are reminded that the Society possesses a comprehensive collection of lantern slides which may be borrowed for lecture purposes.

Cambridge University Aeronautical Society

The following programme of arrangements for Michaelmas Term has been received from the Honorary Secretary, Cambridge University Aeronautical Society :—

October 22nd.—Wing Commander T. R. Cave-Browne-Cave, C.B.E., R.A.F., "The Structure and Machinery of Airships."

October 29th.—Major-General the Rt. Hon. J. E. B. Seely, C.M.G., D.S.O., M.P., "Aviation."

November 5th.—Squadron Leader J. A. G. de Courcy, M.C., R.A.F., "Special Flying Facilities."

November 12th.—G. S. Wilkinson, Esq., "The Heart of a Lion."

November 19th.—C. G. Grey, Esq., "Aircraft in the Next War."

November 26th.—Lieutenant-Commander S. E. Deacon, R.N., "The Air Port of Croydon."

December 3rd.—Exhibition at Engineering Labs.

December 6th.—Visit to Messrs. Boulton & Paul, Ltd., Aircraft Manufacturers.

Date to be announced later.—Visit to Royal Airship Works, Cardington.

Date to be announced later.—Display of Trick Flying.

Forthcoming Arrangements.

Tuesday, November 11th, 5.30 p.m.—Council Meeting.

Thursday, November 13th, 5.30 p.m.—In the Library, Professor L. Bairstow, "Skin Friction."

Thursday, November 27th, 5.30 p.m.—In the Library, Dr. G. C. Simpson, "Thunderstorms."

Monday, December 1st, 8.0 p.m.—*Scottish Branch.*—Mr. F. T. Courtney, "The Difficulties of Aeroplane Experimental Development."

Thursday, December 4th, 5.30 p.m.—In the Library, Colonel F. Searle, "The Maintenance of Commercial Aircraft."

International Congress of Applied Mechanics

The papers read at the International Congress on Applied Mechanics held at Delft from April 22nd to April 26th this year are to be published in a volume of proceedings. Members desiring to obtain copies can order them at the reduced price of 13 florins (Dutch) up to January 1st, 1925. After that date the price will be increased to 18 florins, both prices including postage. Orders should be sent to the Committee, Nieuwe Laan 76, Delft, Holland.

Among the papers read in English were :—C. B. Biezeno : "Graphical and numerical methods for solving stress problems." E. G. Coker : "Some engineering problems of stress distribution." A. A. Griffith : "The use of soap films in solving stress problems." A. A. Griffith : "The theory of rupture." G. I. Taylor : "Experiments with rotating fluids." F. M. Burgers : "The motion of a fluid in the boundary layer along a plane surface." Sir Napier Shaw : "The physical structure of the atmosphere regarded from the dynamical point of view." A. N. Kriloff : "On the numerical integration of differential equations." R. V. Southwell : "Note on the stability under shearing forces of a flat elastic strip, and an analogy with the problem of the stability of laminar fluid motion." B. P. Haigh : "Theory of rupture in fatigue." N. Zeilon : "On potential problems in the theory of fluid resistance." S. Brodetsky : "Vortex

motion." Max. M. Munk: "The simplifying assumptions, reducing the strict applicability of classical hydrodynamics to practical aeronautical computations." A. G. v. Baumhauer: "Some notes on helicopters."

Other papers of aeronautical interest were read by L. Prandtl, Th. von Karman, H. Solberg, v. Bjerknes, C. Witoszynski, C. Koning, G. Kempf and others.

Correction

The text under the illustrations on pages 483 and 484 of Mr. H. Hamshaw Thomas' paper in the July JOURNAL should be interchanged.

W. LOCKWOOD MARSH, *Secretary.*

PROCEEDINGS

First Meeting, 60th Session.

A meeting of the Royal Aeronautical Society was held in the Society's Library on Thursday, October 2nd, 1924, when Lieutenant-Colonel H. T. Tizard, on assuming office as Chairman, read his inaugural address on "Commonsense and Aeronautics."

Colonel Tizard said that before reading his paper he had a very pleasant duty to perform, and that was to award the Society's Silver Medal to Mrs. Hill for her to convey to her husband, Squadron Leader R. M. Hill, M.C., A.F.C., A.F.R.Ae.S., for his paper on "The Manœuvres of Inverted Flight." It was a particularly pleasant duty for personal reasons so far as he was concerned, and he thought the whole Society would welcome the opportunity of giving some public recognition to Squadron Leader Hill's work. He expected that the members knew that the medal was given for the best paper published in the Journal during the year. The papers were considered very carefully, and the Council had no hesitation whatever in making the award. The paper reflected not only Squadron Leader Hill's skill as a pilot, and his keen experimental insight, but also his unusual powers of exposition. He had very great pleasure in handing the medal to Mrs. Hill.

COMMONSENSE AND AERONAUTICS

BY LIEUTENANT-COLONEL H. T. TIZARD, A.F.C., FELLOW.

Before beginning the main subject of my lecture, the Society may perhaps wish me to refer to some of the outstanding events of the year.

The honour of the first flight round the world has fallen to the countrymen of Wilbur and Orville Wright, and well have they deserved it. We can realise to the full the courage, endurance and skill that they brought to their task; and we can share to the full the disappointment of those of their own party, and of their friendly French and British competitors, who had the misfortune to fall by the way.

The flights round Australia, though less spectacular, and covering less distance, are perhaps equally worthy of recognition. With practically no organisation, complete reliance had to be placed on the aircraft and engines, as well as on the pilots; there was no possibility of effecting any but quite minor replacements. That both flights were successfully accomplished is greatly to the credit not only of those who took part in them, but also of the British manufacturers concerned.

Finally, Mr. Alan Cobham has shown us repeatedly what can be done by the best combination of machine and man. Flights such as his afford perhaps more direct encouragement than any others to those who look forward to the establishment of air transport as a normal and commonplace industry.

Someone has remarked, rather cynically, that the chief lesson of the round-the-world flight is that it is quicker to go round by sea. But these pioneer flights are of real practical value: they reveal hidden defects; show what is

possible and what is not possible; and enable plans to be laid out more certainly for the future. Incidentally, it is of interest to note that all the successful long-distance flights have been accomplished with engines developed and used in the war. This shows how many years of experience it takes at present to put the finishing touches on an aircraft engine—to make it, in fact, as reliable as it is efficient.

I take up my new duties to-night in a distinctly apologetic mood. Unlike my immediate predecessors in office, I cannot claim to have devoted the best part of my life to the study or promotion of aeronautics. For over five years now I have been mainly engaged on other work. These years have passed very quickly; it seems only the other day when we at last had leisure to take stock of the immense advances that were made during the war, and to dream dreams of the future. Perhaps some of us were rather carried away by our enthusiasm at the time; certainly few of us can say that the development of aeronautics since the war has corresponded very closely to our dreams in 1919; nor have many of us been quite consistent in our opinions during these eventful years. We are still learning a hard lesson—the lesson that damage caused by five years of destruction cannot be made good in a day; that it is easier to destroy than to rebuild; and that with a nation, as with an individual, in a state of convalescence, strength must be conserved, not dissipated. It is because steady progress is promoted and not retarded by trying occasionally to get outside our enthusiasm, and to see ourselves as others see us, that I venture to address you on "Commonsense and Aeronautics." It is perhaps a provocative title; it might even lead the unkind to believe that the lecturer was claiming the monopoly of a commonsense view. I make no such absurd pretension; I am using the word in what I take to be its literal meaning, namely, the intelligent thoughts of the ordinary man.

What does the ordinary intelligent taxpayer think about aeronautics? Perhaps his chief thoughts can be summarised as follows:—

(1) The Air Force is a necessity; but let it be as efficient and economical as possible.

(2) Civil aviation is a luxury.

(3) Flying is unsafe.

Let us take these in order, and derive what benefit we can from a consideration of each of them.

There can be no doubt that the British taxpayer is going to keep his Air Force. He is proud of its great, though young, traditions; interested in its doings; and keenly alive to its importance for national defence. But it is equally true to say that he gets a shock when he sees the bill, and that he is right in relying on efficiency rather than numbers. What is the key to efficiency? Courage and discipline? One must face the sorrowful fact that these avail one little if the opponent is better equipped. It takes longer to produce the machine than to train the individual.

I do not intend to waste much time in preaching to the already convinced the vital importance of scientific research and experiment to our youngest service. More has been spoken and written in the last five years about the value of scientific research than ever before in history. Research is rapidly taking a similar place to education in the public mind; there is already a general feeling that it is an excellent thing for somebody else to do. But the recent establishment of a Directorate of Scientific Research at the Air Ministry, which has met with the wholehearted approval of this Society, prompts me to say a few words on some aspects of military research which perhaps escape the attention of the general public.

One often gets the impression from debates in Parliament, and from articles in the Press, that military research is believed to result solely in the evolution of new methods of destruction, and to have no real value in itself. Nothing, surely, could be further from the truth. I would go so far as to say that if all possibility of war were by some miracle to disappear, the cessation of all forms of military research, and the removal of all the powerful incentive behind it, would have a marked effect on the progress of industrial research. In scores of ways, direct and indirect, the results of research undertaken primarily to meet service requirements are continually filtering through to, and benefiting, the industries of the country. The whole aim of such applied scientific research is to produce the best, and not the most paying; only the best is good enough. Few, if any, industrial organisations in this country could afford to carry out the kind of work that is pursued in the Service experimental establishments, even if they were convinced of its value; and yet it is just this kind of work that leads in the long run to important industrial advances. Experimental work is now in progress at Farnborough, which, even if it fails in its immediate object, is destined to exert a profound influence on other industries. In the making of an aeroplane, many branches of science bear their share; and in turn many industries stand to benefit. Not only the metallurgical and engineering industries—to quote two of the most obvious—but even such apparently remote industries as fishing and mining bear the imprint of work undertaken to increase the efficiency of the Air Force. Underneath all is a growing volume of fundamental and far-reaching scientific research, which owes its inspiration directly to the needs of aeronautics. The Society can rest confident that in supporting to the utmost a wise expenditure on aeronautical research they are not only helping to secure efficiency and economy in the Air Force, but are also promoting work of permanent value to the nation.

There is only one danger that I see in this insistence on the value of scientific work. It is that the scientific worker may continue to be regarded, as he undoubtedly has been in the past, as a peculiar being, to be segregated from his fellow-men and left to the evolutions of his inner consciousness. There will always be men of genius who, in the pursuit of knowledge for its own sake, will strike out new paths for others to follow. But most of us, it must be admitted, need the inspiration of practical aims to call forth our best work. In applied aeronautical research there is room for everybody. A vast amount of important work waiting to be done needs no deep scientific knowledge; scientific method, and a logical and unprejudiced mind, will carry one far. There are officers in the executive branch of the Royal Air Force, the value of whose judgment, criticism and experimental skill is gratefully recognised by the scientific world. To such an one, the Society has awarded its Silver Medal to-night. We want more of them. We look for the closest co-operation between the executive and scientific branches; between, in short, the user and producer. The war showed us the value of that; but we seem to have been forgetting the lesson. Our little aeronautical world has tended to be divided up into so-called scientists (a small, slightly troublesome, and wholly incomprehensible sect) and practical men (who do the work). Placed on close but parallel lines, they only meet at infinity. Four years of experience on the Aeronautical Research Committee has taught me the danger of this; but we hope that the new organisation will avoid it.

We look, too, to the new Directorate for some direct benefit to the Society. Like many other scientific societies since the war, we struggle for existence. Our list of members contains only 55 out of upwards of 3,000 serving officers of the Air Force. Perhaps this may be partly accounted for by the generosity of the Government in purchasing regularly fifty copies of our Journal for free distribution to the squadrons, where they lie on the mess tables competing uneasily with the weekly illustrated papers. Be this as it may, shall we venture to judge to some extent the success of the new organisation by the number of recruits it brings us?

I pass now to the second of the thoughts that I attribute to the ordinary man—Is civil aviation a luxury? All activities that consume more than they produce are luxuries, unless they bear within them the promise of greater productivity in the future. We are passing through a period when every item of unproductive national expenditure has to be scrutinised with more than usual care. That expenditure on civil aviation has escaped a really critical scrutiny I attribute to two causes—one that many people have a vague idea that it is a necessary factor in the aerial defence of the country; the other that the public mind is preoccupied with more important matters. All the more reason why we who honestly advocate expenditure on civil aviation should examine our motives and methods and ask ourselves whether they can be justified.

The majority of you will probably agree that only on one condition will civil air transport become a real part of the economic life of the nation, and at the same time a real factor in the defence of the country. The one condition is that it pays its way. So long as it is carried on at a loss, so long will it be negligible for defence purposes. Machines developed for civil purposes will never be of more than trivial importance in aerial warfare; what will be of importance is the development of a large and healthy industry, and the adoption of aircraft by a considerable section of the community, either as a normal means of transport, or as an indispensable adjunct to other industries. Neither of these events will come about until civil aviation pays its way.

It is well known that air transport does not pay its way, and does not nearly pay its way. For five years the nation's money has been spent in civil aviation, and at the end of them we are not much nearer our ultimate goal. I am not going to indulge in vain criticisms of the past; indeed, any would-be critic should first persuade himself that he would have done better if in control. I am merely trying to state the facts. Experience, then, has taught us that no amount of good business management can make air transport pay at present in this country. If we could afford to put the best business men in the country in charge of air transport, which we obviously cannot, as they have more immediately important things to do, and if we provided them with the best material available to-day, they would find themselves faced by an impossible task. The only possible means of making air transport pay is by a substantial, perhaps revolutionary, improvement in design of aircraft and engines; the whole future depends on experimental work. It is because most of us believe that the improvements will come that we support this attack on the harassed taxpayer. We believe that in the end he will arise and call the Director of Civil Aviation blessed; and in the meantime we hope he will not feel called upon to arise too soon.

If you accept these statements, there is only one logical conclusion. It is that air transport cannot yet be regarded as a business; it is simply a large scale experiment. It may be regarded as a natural and necessary consequence of research and experimental work in the laboratory and workshop. As such, it has plenty of parallels in other industries. Every year, large sums of money are, and must be, spent on full scale research, without any hope of immediate remuneration. All industrial research that has a promising issue on the small scale must be tried out carefully on the large scale before its conclusions can be finally adopted. Often it is only on the large scale that those modifications and improvements are introduced which make the difference between success and failure. For air transport to have any prospect of success, it must be operated on the same sound principles that many years' experience have shown to be essential in the conduct of other industrial research.

What do large scale experiments involve in the case of air transport? They involve the conduct under scientifically-controlled conditions of comparative trials on all questions upon which experts hold definitely different views. For instance, on the relative merits of heavily and lightly-loaded machines; of light, costly,

and highly-efficient engines and comparatively heavy, slow-speed engines of less initial cost; of multi-engined and single-engined aircraft, and so on. The most economic size of machine and length of stage are problems which can also only be settled by properly-controlled trials extending over a long period. More important still is the need for the adoption and thorough trial of any improvement indicated by small scale work. Every development in the direction of safer and more economic flight, which has successfully passed preliminary tests, must be tried out promptly and properly on the large scale for progress to be continuous and assured. All this necessitates the very closest co-operation between the scientific and the business management; a complete interchange of information, and a mutual confidence. In other industrial work, the research staff has complete control of the laboratory stage; the large scale work is controlled by the research and technical staff in co-operation, with the help of the advice and criticism of the business side; it is only in the third stage, when the process is a proved success, that the research staff practically drops out.

In the constitution of "Imperial Airways," there is much that fits in admirably with this conception of a large scale experiment. The financial support from Government is generous, and guaranteed for a period of years, long enough to enable a definite conclusion to be reached if the experiment is properly conducted; the obligation on the company's part to complete at least a million miles' travel a year should enable competitive trials of different types and combinations of aircraft and engines to be carried out on a sufficient scale to give reliable data. Most of what I have said will be found to be explicitly or implicitly contained in the Hambling Committee Report, which has resulted in a scheme to which evidently much care and thought has been given, and which has in it all the essential elements of success. But the prospectus of the company strikes a different note—the note of immediate, though artificial, "profits." If the private investors, who have risked their money in spite of the warning of the late Secretary of State for Air, look for an immediate return, they can get it; but only, in my opinion, at the risk of eventually losing their capital. But if they are prepared to take a long-sighted view, and devote what funds are available in the first few years to development work—as is done in all other large scale experimental work—they stand a much greater chance of eventual success.

"Flying is unsafe." Here the commonsense view is undoubtedly right. It *is* unsafe. Not dangerous but unsafe. About as unsafe, let us say, as mountaineering, but hardly as unsafe as motor-racing. It is no good trying to pretend to the ordinary man that air transport compares in safety favourably with other forms of transport. Tell him that there are decimal nought something passengers killed per 1,000 passengers carried, as I have seen statistics put, and he simply gets suspicious; the British public, like Randolph Churchill, never could understand those damned dots. Tell him that in five years only six passengers have been killed out of 40,000 carried, and he thinks there must be a catch somewhere as it sounds too small. In fact, it is much too large. There are about 1,200,000,000 railway passenger tickets sold by the great railway companies each year in Great Britain. If six railway passengers were killed for every 40,000 carried, the death roll on the railways would be 180,000 a year, whereas in 1922 it actually was 78. Perhaps this comparison is not wholly fair; the railway passenger does not travel so far on the average as the passenger by air. If we make the comparison on the basis of passenger-miles, we find that one railway passenger was killed in 1922 for every 170,000,000 passenger-miles; while on the airways one has been killed for every 1,300,000 passenger-miles. It would probably be right to say that travelling by air is at least 150 times as unsafe as travelling by railway. There is nothing to be particularly alarmed at in this; no season ticket holder on the railways worries very much about the prospect of accident. But at the same time there is nothing to be gained by

trying to conceal from oneself, and from the taxpayer, that air transport is not a perfectly safe means of transport when we know that it must be made 100 times safer before it can be a reasonable commercial proposition. Considering the nature of the aircraft engine, it is astonishing how reliable it is; considering the newness of the science, it is astonishing how stable and strong an aeroplane can be made; but it is equally true to say that no effort must be spared in making the one more reliable, and the other more stable and foolproof.

The ordinary man pays very little attention to the optimism of the enthusiast on this subject; what he looks at are the insurance rates. The insurance rate for a passenger flying from London to Paris is about 10/- per £1,000; if he wants to insure himself for £5,000, which would not be an excessive amount for a man with a family, he would have to pay £2 10s., *i.e.*, well over one-third of his fare. I have before me one of those insurance coupons which are given away in diaries. For the sum of sixpence a year it is possible to insure one's life for £1,000 if killed by an accident to any train or other vehicle plying for hire in the United Kingdom, and to obtain various other benefits in case of injury. There must be hundreds of thousands of people who travel over 3,000 miles yearly in their daily journeys to and from their work in London. Each of these people can insure themselves for £1,000 by paying a penny for every 500 miles travelled; while the aircraft passenger has to pay a penny for two miles. Small wonder that the business man who is not well off does not take kindly to air transport as a normal means of travel. On the same coupon there is an offer which gives a significant idea of the general opinion about the safety of air travel. For three shillings you are offered a life insurance of £10, without medical examination; but death by "suicide or by war or by aeronautics, or while in a state of intoxication" is excluded from this benefit. Note the subtle gradation; indulging in flying is, I take it, slightly less reprehensible than fighting, but more so than being in a state of intoxication.

If we examine such meagre statistics as exist, we cannot reasonably say that companies who make a speciality of insuring the lives of passengers who travel by air are asking too high a premium. They are on very uncertain ground, and this will continue so long as air transport is on such a small scale. Until very many more people travel by air, there is little hope of premiums being substantially reduced; and yet I firmly believe that the present insurance rates prevent a large number of people travelling by air who would like to do so. It is not so much perhaps the rate of insurance as the nuisance of being under the necessity of taking a special insurance. It brings what risk there is home to one in an obvious manner; and although not many of us are under the delusion that our lives are particularly valuable to the country, or that our places would not be filled with ease, and even with some satisfaction, in the unfortunate event of our untimely decease, we know, being sensible men, that our lives are valuable to our dependents, and we are not disposed to take unnecessary risks which may injure them. This sounds unenterprising, but it is "commonsense." The high rates of insurance, and the necessity of insuring specially if one wishes to make regular use of air transport, excludes that class of passenger whom it is most important to attract; the business man at the beginning or in the middle of his precarious career. He is the man to whom air travel may be a real advantage, and not merely an exhilarating adventure.

Let me give you two more examples of insurance rates. A civilian member of this Society, well known as a first-class pilot, is compelled to pay 3 per cent. per annum on the sum for which he is assured, to cover flying risks. This premium does not cover risks of flying on experimental machines, but only on standard, properly-inspected aeroplanes. He is also limited to fifty-five hours' flying a year. He could obtain a whole life insurance to cover all ordinary risks of death at a premium of 1½ per cent. The risk of his death by flying a little over one hour a

week is thus accounted twice as great as the risk of his death by any other cause. How can one expect to attract the best type of men to aeronautical work when such prohibitive premiums are in force? Yet how can one expect to make rapid progress without attracting such men?

My own case is perhaps a more typical ordinary example. After the war I took out an additional life policy with a well-known company. On the proposal form I was asked whether I intended to fly. My answer, so far as I can remember, was to the effect that I had no present intention, but that I had every intention of doing so if and when air transport developed. The result was that flying risks were definitely excluded. An appeal to the better feelings of the directors was without effect; it was only when I started inquiring into their policy 100 years ago when railways were just beginning that they made the concession that in the event of my death by flying all premiums paid would be returned. With this I had to be content, although I knew as well as they did that the concession really meant nothing. I may do almost anything else but fly. I may even commit suicide and the money is paid; the only thing I may not commit is aviation.

Some advance has been made since then. It does not seem to be widely enough known that most of the big life insurance companies allow their policy holders the indulgence of "occasional" flights without additional premium. Most of them, however, require notification, and this in itself is a sufficient deterrent. If you had to notify your insurance company whenever you took a long journey by rail, you would travel far less light-heartedly. We are confronted with a dilemma —air transport will not pay until more people make use of it, and more people won't make use of it while insurance is prohibitive. The only ultimate solution is increased safety, but this will take time, and if insurance companies hold back until sufficient statistical data are collected for them to make fairly accurate calculations of risk, many more years will be lost. I want to make a bold appeal to them to help over an awkward period by accepting all flying risks, for pilots and passengers, without extra premium, in the case of properly-inspected machines. You will probably say, as they certainly would, that they would undoubtedly lose by such a concession. It would be contrary to "commonsense." Well, so it would be, strictly speaking; but strictly speaking it is not commonsense to admit the risk of suicide. I have already said that in the last five years there have been six deaths of passengers by air transport. The total number of deaths of crew and passengers in these five years, by air transport and all other British civilian flying, was 29. The total number of suicides in these years in the United Kingdom was upwards of 18,000. Even at the present rate of accidents, civil aviation would have to increase over 600 times in magnitude before the number of deaths by flying became equal to the number of deaths by suicide. Why is flying to be more discouraged than suicide? Not even the most pessimistic could suggest that it is as dangerous.

But I want to base the appeal to the insurance companies on a higher ground than that of a comparison with suicides. For many years the prosperity of the companies has been steadily growing owing to advances in medical science, sanitation and hygiene. The average annual standardised death-rate in the United Kingdom for the last five years was 11.7 per 1,000. The average rate for the years 1899-1904, just before flying became an accomplished fact, was 16.6 per 1,000. The expectation of life of a man of thirty is now some years longer than it was twenty years ago; he has the pleasure of paying premiums longer than his father. The companies pass on a good proportion of this automatic benefit to the public in the form of reduced premiums to new insurers, and bonuses to the holders of profit-sharing policies. But the fortunate proprietors very naturally get their share, as a glance at the balance sheets will show. What other return do they make for the great financial benefits which science has brought them? Do we hear of large donations to hospitals and to medical research? If these

things be done, they are done by uncommon stealth. What we do know is that when the advance of science in another direction introduces a new industry which is potentially of great importance to the Empire, but which temporarily increases the death-rate by an infinitesimal amount, everybody is discouraged to the maximum extent from taking part in it.

If the insurance companies accepted civilian flying as a normal risk, what would be the position? Air transport cannot possibly grow very much in size until it pays; it will not pay until it is more reliable. The total number of yearly deaths must therefore remain low, although the proportionate risk may be temporarily high. The total cost of such a concession to the companies cannot therefore be great; and they can always help to recoup themselves in another direction by withdrawing the protection they extend at present to would-be suicides —which, after all, is little short of compounding a felony, and the withdrawal of which would surely occasion no public outcry.

Is it too much to expect them to take a long-sighted view, and so earn the gratitude of the aeronautical world at a cost to themselves which it will be difficult to reflect in their dividends. If they do, let me make one more suggestion, namely, that one or more of the directors of Imperial Airways should be nominated by the insurance companies, who would then have the most powerful incentive, and be in the strongest position, to encourage to the utmost all research and experimental work directed to increase the safety of air travel.

Discussion

Lieutenant-Colonel I. A. E. Edwards, who had been asked by Sir Setton Brancker to take his place as he was obliged to be at Lympne, said that first of all he would like to congratulate the lecturer on his extraordinarily interesting lecture, with most of which he agreed. However, there were one or two points to which he would like to take exception. First, Colonel Tizard had said that machines developed for civil air transport would never be of more than trivial importance in war. Of course, that was a very controversial question, but he could not help feeling that any machine which was of real use as an air transport machine and which could fly by night would be of use as a night-bomber. He did not say that the present machines were of such use, but the tendency was that they would be developed for night flying and in that case would in time of war surely be suitable for night-bombing.

Later on the lecturer had said "the only possible way of making air transport pay is by a substantial, perhaps revolutionary, improvement in design of aircraft and engines." Now while he agreed with the last part of that, he took exception to the "only possible." In the case of one of the machines they had in operation already (the Handley Page W.8, carrying fourteen passengers) the running costs were somewhere in the neighbourhood of £4 per passenger. That, he admitted, was high enough, and undoubtedly they had got to improve both aircraft and engines. The proportion to the total cost of overhead charges for this machine was about 65 per cent. It seemed to him, therefore, that the great solution was to get down those overhead charges. The only way they could do that was to increase the number of services, and to do that they must have more passengers. One of the most important things they had to do to bring down the cost per passenger was to split up these very heavy overhead charges among more machines. With improved machines they hoped also to reduce the running costs to a lower figure, though he did not consider that even the present figure of £4 could be considered enormous.

As regards accidents, while undoubtedly the accident rates were high, he thought it was a little unfair to compare aircraft accidents, or deaths due to

aircraft accidents, with ordinary train accidents as a whole. He thought one should compare them with express train accidents. He had tried on one or two occasions to find what were the proportions between express and slow passenger train accidents, but it was extremely difficult to separate them. With regard to the method of expressing the number of accidents to aircraft, the using of a percentage or so many noughts was impossible, but if one took the number up to August last of deaths due to aircraft accidents, one got a distance equal to 125 times round the world, during which only five people were killed.

With regard to insurance, he had himself recently taken out a policy in which the company agreed to give him a full life policy, and the only difference made from an ordinary one was that if he got killed by an aircraft accident during the first ten years, only 80 per cent. of the full benefit would be paid. He thought that was reasonable. He thanked the lecturer for an extraordinarily interesting lecture.

Mr. GRIFFITH BREWER added his thanks to Colonel Edwards's for the extraordinarily interesting lecture they had heard. He would suggest that if the life insurance companies accepted every person who flew, at ordinary rates of insurance, in the end they would still be in pocket, even though paying the full amount on each death, because such a large number actually fly. He would like to point out in regard to the lecturer's reference to suicides that the insurance companies do not pay insurance on a life policy if the holder committed suicide within a year.

Major WIMPERIS: The lecturer had spoken of the dangers of flying and what should be done to remedy them. As he had mentioned, engines were rapidly being developed and improvements being reached which would lead to great improvements in reliability. As regards the machines themselves, the most useful improvement would be to enable a machine to land at a much lower speed than at present, and to be made more controllable at low speeds. Both subjects were being closely studied by the Aeronautical Research Committee, with the full support of the Air Ministry. The difficulties that arise in landing in fog are another problem. It was impossible to foretell when fog might come, or how thick it would be or how far it would spread. It could not be dissolved or pumped away except at quite prohibitive cost. Recently some very useful work had been done at Farnborough on a small scale apparatus, by means of which a pilot would not only be guided to an aerodrome suitably equipped, but would also be able to read off his height even when within but twenty or thirty feet of the ground. This device was only in the model stage at present, but when tried on full scale, he believed it would be found to be a real landing proposition.

Wing Commander CAVE-BROWNE-CAVE suggested that in considering the real, as distinct from the profit-making, value of civil aviation, one must realise how important is the experience gained in the course of the million hours flown. The next step after research and experiment is the development of first-class reliability, and this involves long trial under carefully observed and recorded conditions. British civil aircraft are under such close observation that the necessary experience can be gained from them in the course of their ordinary work. The cost involved in this step is therefore a fraction of that which would be incurred if special flying were required to develop the final stages of reliability.

The small proportion of serving officers of the Royal Air Force who were members of the Society was less remarkable if it was realised how few were ever able to attend the lectures and discussions. The Journals supplied to R.A.F. messes were very widely read, not only at Establishments like Grain, where technical interest was naturally high. He had been surprised to find recently how much the Journal had been read by officers he had met in the Fleet or on their return from overseas.

Mr. J. L. PRITCHARD (*communicated*): I have read with very great interest Colonel Tizard's lecture on "Commonsense and Aeronautics," and I should like to congratulate him upon his very great courage in delivering that lecture. It requires great courage for the Chairman of the Society to declare that flying is unsafe from the point of view of the man in the street and to back it up with brutal statistics.

The point of view of the man in the street is too often ignored by the engineer and the scientist. Yet the man in the street is right in most instances on general principles, though he may not be able to distinguish between y dot and y double dot, and speed to him is the same as velocity. For many years it has been my province to deal with the man in the street and to ascertain his viewpoint. Brought up as a mathematician and flung into Fleet Street, I am able dimly sometimes to understand both points of view.

Colonel Tizard has hit a large nail a very shrewd blow on the head by his comparison of the safety of flying with that of railway travelling. The point of view of the man in the street is very much this: "Oh, yes, it's all right so long as you keep going. But what's going to happen if the engine goes wrong or the thing catches fire? How can I jump, even if I am near the ground, out of a bally thing going at fifty miles an hour?"

If a motor-car engine stops or a railway engine jibs, the man in the street gets out, curses a little because he will be late at his destination, and thinks no more about it. Certainly he doesn't spend the rest of his life telling his friends what a narrow squeak he had of being killed, as he undoubtedly would if he had been an unwilling participant in a forced landing, due to engine failure, on a newly-ploughed field, say.

There is a point here, too, which makes the public suspicious if not definitely uneasy. When there is a bad railway accident a public inquiry is held and a definite statement is afterwards made, where possible, of the cause of the accident, and this statement is in clear language. When an aeroplane accident happens there is an inquiry certainly, but how many of the public afterwards learn what really happened? How many of the public, for example, know the real cause of the R.38 disaster? And too often, in any case, the cause of the accident is failure of the flying machine in some part, either constructional or in the engine. How often is there a railway accident because the engine has failed or the coaches break away from one another? More often than not the cause of failure is something extraneous to the train, another train, an obstruction on the line, a signalman's error.

The one thing about an aeroplane which makes the average man in the street think hard before flying is the landing speed of the machine. I have been for some years one of those lost souls in aeronautics who believe in experimenting with heliocopters because I am convinced that when the man in the street sees a flying machine slow up, *stop*, and gently land, he will get a confidence in flying of which no amount of talking will otherwise convince him. The heliocopter may be useless from most points of view, but if experiments with it bring about a very much lower landing speed, then so much the better for the future of aeronautics. It is no use telling the man in the street that the pilot is the most skilful pilot in the world and can land on one wheel on the side of a mountain without endangering the lives of his passengers. Always there is the thought that the pilot may have a heart attack or something else, and where is the poor passenger? On the road there is a more sporting chance of coming through, and there are levers to pull and brakes to put on, of which he understands a little at any rate. In an aeroplane it is all one dark mystery, and he is not allowed to know anything he might try in an emergency. In the language of the man in the street, if the pilot does collapse, those in the aeroplane are for it.

A lower landing speed is vital from the point of view of the man in the street. He must feel he can jump for it and have a chance of getting out safely. Despite aerodynamics, despite mathematical equations running across the page, and the like, the time is bound to come when the aeroplane, if it is to become as popular as the motor-car, will not only be safe in the air, a safety which depends only upon sound construction and design after all, but will be safe approaching the ground and landing on it. The man in the street inevitably makes the comparison between the bird and the aeroplane. I believe I am right in saying that no matter what the top speed of a bird may be, its landing speed is less than ten miles an hour. At any rate, the observation is true of most birds. The carrier pigeon reaches a top speed of over 100 miles an hour, but it certainly does not shoot into the opening of its cote on its return home at a speed of thirty miles an hour, say.

With regard to insurance and suicide, I do not think Colonel Tizard is quite fair in his statistics. He says there are upwards of 18,000 suicides in the United Kingdom in the five years he is reviewing, and rather implies they were all insured. I should like to know the number of suicides who were insured and for whom the companies paid out. Moreover, I am not sure about the average policy and the suicide clause. In my life policy, for example, I am distinctly barred from committing suicide until I have paid one year's premiums and until one year has elapsed from the issuing of the policy. Perhaps in a similar way an insurance company may offer a lower aviation premium after the insuree has flown a certain number of times or a certain mileage without being killed! There is nothing, however, to prevent any aviation company carrying out the insurance themselves, and if they are so certain about the safety of flying they will be able to offer a very attractive premium. Perhaps when they have gone a little into the rates charged by insurance companies they will not be quite so enthusiastic about low premiums.

The appeal of Colonel Tizard to the insurance companies to bear some of the risk will fall upon deaf ears. After all, insurance companies have very large and palatial offices to keep up, they have to keep staffs out of all proportion to their business, and there are bonuses to pay, and heaven alone knows what else, to say nothing of the many millions to be kept in a reserve fund. It is not fair to them to expect them to think in thousands when they have been so accustomed to the word million. An interesting thing to find out would be the number of directors of insurance companies who have flown.

Colonel Tizard asks why flying is to be more discouraged than suicide. Well, after all is said and done, suicide is strictly a personal affair, while flying involves trusting one's life into another man's hands. Even the most hardened suicide doesn't go to a friend and say "Please kill me." He prefers his own way out and can take his choice of the razor, the revolver or the gas stove, if he doesn't like water. In an aeroplane crashing at fifty miles an hour there is no time for rumination and there is no choice. Besides, it is cheaper to commit suicide than to go for a flight, as insurance rates are.

Colonel Tizard, in reply to the discussion, said with regard to Colonel Edwards's remarks that he agreed that the utility of civil aviation machines in war was a very controversial point. He knew that there were various opinions, but he felt justified in recording his view that, looking to development as far as it could be foreseen, civil aviation machines would become less and less useful as war machines, except perhaps to fill a gap at the outbreak of war. Colonel Edwards had challenged his statement that "the only possible way to make air transport pay was to make substantial improvements in engines and design." He, however, held to his view, after considering the points raised by Colonel Edwards, that everything else was of minor importance compared to that of technical development. As to the present running costs, he did not think it

possible to discuss these without the actual figures, and he would like to suggest that these details were not so readily available as they might be. He knew they were available in the Air Ministry, and that there were perhaps some objections to making them public. He maintained that one must know what the overhead costs included before discussing them. If they included upkeep, then they would not be considered overheads by many business firms. Such figures as were supplied him, which he was not at liberty to make public, led him to make the statements in the paper. Colonel Edwards had mentioned the figure of £4. He did not think the public minded paying for speed if they could get it when they wanted it, as they willingly paid twelve times as much for a taxi as for a motor-bus. If they could get to Paris with safety in a certain time they would pay. Reliability was what was wanted.

He was quite serious with regard to insurance policies. He was very much interested to hear Colonel Edwards's experiences, which were different from his. The Air Ministry would do a very useful work if they could persuade the companies to publish the fact that they would issue such policies. Many people did not know that such concessions were made as Colonel Edwards had mentioned.

Major Wimperis was most interesting. The information as to the developments proceeding at Farnborough in connection with landing in fog would be quite new to the general public. Methods for landing in fog were certainly of the greatest importance and would be of very material assistance to reliability.

There was just one remark that Mr. Brewer had made that he would like to comment on. It was quite true that an insurance policy did not cover death by suicide within the first year; the companies might, if they liked, introduce a similar condition with respect to aviation. In fact, the substitution of the word "aviation" for the word "suicide" would meet his points. He agreed that in the end insurance companies would gain, and not lose, by accepting flying risks.

With regard to Commander Cave-Browne-Cave's remarks, he hoped that he had not given the impression in his paper that he thought that civil aviation on the present scale was of no value. On the contrary, regarding it as a large scale experiment, it was of great value, for reasons indicated by Commander Cave. Members of the Society would be glad to hear that the Journal was widely read in the Air Force. He wished that officers could be encouraged to communicate papers to the Journal more freely. Such papers would certainly be welcomed.

Reply to Mr. J. L. Pritchard: I do not suggest that all the 18,000 suicides of the last five years were insured; I only suggest that they could have been. If flying risks were accepted in the ordinary way by life insurance companies, it does not follow that all passengers' lives would be insured; for instance, there would probably be a good many foreigners travelling by air in British machines who were not insured by British companies.

FRENCH AERONAUTICAL SOCIETIES

A Footnote to the History of the Royal Aeronautical Society

BY LIEUTENANT-COLONEL W. LOCKWOOD MARSH.

For many years the claim has been put forward that the Royal Aeronautical Society is the oldest aeronautical body in the world through its unbroken existence since its inception on January 12th, 1866. This is a proud title—though not perhaps so proud as that of being the most active and up-to-date—which it has interested the writer to examine in the light of various documents bearing on the history of similar French societies which he possesses in his own collection of early aeronautical literature or has found in the admirably complete historical library at 7, Albemarle Street. In the hope that these researches may prove of interest to others, and of assistance to future historians, he has set down the results here in the form of notes on the various French societies, grouped under the four heads into which they seem to fall, the authorities for various statements made being inserted in brackets.

First Société Aérostatique

The first Aeronautical Society to be formed appears to have been "La Société Aérostatique et Météorologique de France," founded by Dupuis Delcourt about October, 1852. It published a quarterly "Bulletin," of which I have a copy of the 4th number (July-October, 1853), which was the last to be issued ("L'Aéronaute," Vol. II. (1869) at p. 102.)[1] The Committee of the Society met, by Rule, four times a year, on the first Sunday in January, April, July and October, and the annual general meeting was fixed by the rules for the 1st May in each year. In addition to these meetings, "conferences" were regularly held on the first and third Saturdays in each month at 1.0 o'clock. The offices were at 21, Rue de l'Oratoire-des-Champs-Elysées, Paris. ("Extracts from the Rules" on the back page of cover: "Bulletin trimestriel No. 4.")

The "Bulletin," it is interesting to note, printed several communications from Sir George Cayley. By September, 1853, the membership of the Society numbered more than 100. The exact date of its demise is not clear, though it appears to have still existed as late as 1860 ("L'Aéronaute," I., 52), or even later, since I have recently been shown a pamphlet dated 1863, in which the author describes himself as "Membre de la Société Aérostatique. . . .",[2] though of course this is not conclusive of its continuing existence at that date. A reference to its connection with a later Society will be found below.

Société d'Encouragement

On 15th January, 1864, "Nadar" (Felix Tournachon), G. de la Landelle and the Vicomte Ponton d'Amécourt, at a meeting at the house of the latter of sixty persons interested, formed the "Société (Provisoire) de Navigation Aérienne, which is also sometimes referred to as "The Société (Provisoire) d'Aviation."[3] This body only lasted under this name for a short time, as it

[1] All references to "L'Aéronaute" are to the second publication of the name (1868-1010) cited by Hureau de Villeneuve. In 1911 it was absorbed in "La Technique Aéronautique," where it still appears as the title of the official announcements of the "Société Française de Navigation Aérienne."

[2] "Chemins de l'Air. Application de la Vapeur à la Direction des Aerostats Captifs. Appareil du Dr. Pierre Moreaud."

[3] An interesting note in "L'Aéronaute" (I. 03) attributes the invention of the word "Aviation" (from Lat. *avis* and *actio*) to de la Landelle.

evolved into a more formally constituted body, which was given the somewhat clumsy title, "Société d'Encouragement pour la Locomotion Aérienne au moyen d'Appareils plus lourds que l'Air." (Société d'Encouragment. . . . Rapport, Premier Exercice 1864). This Society adopted as its official organ a paper called "L'Aéronaute," which "Nadar" had founded in 1863, but of which only five numbers appeared. It seems to have appealed particularly to the literary world, as not only was Jules Verne one of the officials, but numbered among its members were George Sand, Victor Hugo and the two Dumas. The list of members published at the end of the Report for 1865 contains over 300 names. The Society nevertheless had only a short life, as it had apparently become extinct by 1869 ("L'Aéronaute," II., 105).

Second Société Aérostatique

On the 17th May, 1865, was founded the (second) "Société Aérostatique et Météorologique de France," with Ponton d'Amécourt as President (Rapport, Années 1865 et 1866). The connection between this and Dupuis-Delcourt's previous society of the same name will be referred to in a moment. Owing to a desire to include within its purview heavier-than-air machines as well as balloons, the title of this Society was changed to "La Société *Aéronautique* et Meteorologique de France" in January, 1869. ("L'Aéronaute," II., 31.) In the meantime, in April, 1868, an official publication was started under the editorship of Abel Hureau de Villeneuve. By permission of "Nadar," the title of his earlier publication "L'Aéronaute" was adopted, and the paper continued to appear first monthly and later weekly, down to December 31st, 1910. It is to this paper that the references in these notes relate.

It is not without interest that in the first Annual Report of this Society (already referred to), which covered the years 1865 and 1866, of which a copy recently came into the possession of the writer, it is recorded that at a meeting on April 28th, 1866, it was decided to seek membership ("que nous nous ferions inscrire comme membre") of the Aeronautical Society of Great Britain. I find a record of this in the Society's first Council Minute Book in the minutes of the meeting of May 23rd, 1866, in the following terms: "The Honorary Secretary read a communication from the President of the Aerostatic and Meteorological Society of France desiring a joint co-operation for the attainment of the objects contemplated by both Societies." To this letter a suitable reply, the exact terms of which are not on record, was sent over the signature of the Duke of Argyll. Thereafter, co-operation appears to have been both close and cordial; for Hureau de Villeneuve officially represented the French Society at the Society's exhibition at the Crystal Palace in 1868 and looked after the interests of the French exhibitors there, and subsequently wrote a long critical description of the exhibition which appeared serially in "L'Aéronaute," commencing with the issue for July, 1868, and continuing at intervals until the fourteenth and last article appeared in October, 1870. At the British Society's Council Meeting of June 24th, 1868, de Villeneuve was "introduced" to the Council, and most of the early annual reports appear in translated form in the pages of "L'Aéronaute." As further evidence of this co-operation, the Duke of Argyll (the A.S.G.B.'s President) contributed a series of articles on "The Natural Laws Applied in the Flight of Birds" to "L'Aéronaute" during 1868, while Ponton d'Amécourt, the President of the French Society, exhibited a beautifully-made aluminium model steam helicopter at the Aeronautical Society's 1868 Exhibition, which is now in the French Government Aeronautical Museum at Chalais Meudon.

The first indication of a connection between what may perhaps be called de Villeneuve's Society and the earlier body of the same name founded by Dupuis Delcourt is to be found in the "Avis" printed on the back cover of the first annual report referred to above. The claim is there made that "This

Society, essentially eclectic, is the oldest of all those founded to encourage and help effectively those who work for the realisation of atmospherical navigation." Inside we find the Treasurer referring to expenditure on the "Crown" placed in the name of the members on the tomb of "notre honorable et regretté Dupuis Delcourt, *notre fondateur.*" A second pointer in this direction is the fact that the next annual report, covering the work done during 1866 and 1867, bears the imprint "15th year."[4] Finally, a letter (pregnant with further interest for a reason which will appear in a moment) read by Crocé-Spinelli, one of the Vice-Presidents, at a meeting of the Société Aéronautique on July 25th, 1872, commences: "For a long time there have been in the midst of our Society two groups with quite distinct tendencies. The first considers this Society as the continuation of the earlier (ancienne) Société Aérostatique et Météorologique de France, founded by Dupuis Delcourt and approved by the Minister of Public Instruction. The second, not sharing this view, has wished to direct the Society in a different direction to that of the first Society. The early members, in order to meet their new colleagues, agreed to adopt the title of Société Aéronautique et Météorologique de France (see above), a title which has now become hampering (funeste), since it is not the name under which the Society was legally constituted."

Société Française de Navigation Aérienne

The upshot of this letter was to announce the resignation and intention to form a new Society of the signatories; who included J. Crocé-Spinelli and Motard (Vice-Presidents), de Villeneuve (General Secretary), A. Saco, F. Michel, and O. Frion (Associate Secretaries), Felix Caron (Treasurer). This was followed a fortnight later, on the 12th August, by the first meeting of the "Société Française de Navigation Aérienne" with "L'Aéronaute" as its official organ. It only remains to say that no further mention of the Société Aéronautique has been traced, whereas the new Society has continued to exist ever since, its present official organ being "La Technique Aéronautique," in which "L'Aéronaute" became absorbed on March 1st, 1911.

We find, then, a series of French aeronautical societies from 1852 to the present day, not in unbroken succession as entities, but with connecting links in the form of personalities: Dupuis-Delcourt's "Société Aérostatique" (1852-1860, and possibly later), Ponton d'Amécourt and Nadar's "Société de Navigation Aérienne," which became the "Société d'Encouragement de Navigation Aérienne" (1864-1869). Meanwhile, Ponton d'Amécourt had become President of the second Société Aérostatique (1865),[5] which changed its name in 1869 to Société Aéronautique, and lasted in that form until 1872, when its Vice-President, Crocé-Spinelli, became President of the off-shoot Société Française de Navigation Aérienne, which exists to-day with Lieutenant-Colonel Paul Renard as President. To complete the chain we find Ponton d'Amécourt (President of the Société Aéronautique at the time of the split in 1872) as President of the off-shoot Société de Navigation Aérienne in 1877, five years later, while on the split Hureau de Villeneuve transferred the allegiance of "L'Aéronaute" to the new body.

The result of this examination of the history of French Aeronautical Societies is therefore to provide definite endorsement of the Royal Aeronautical Society's claim to be the oldest aeronautical body in the world, with a continuous existence of nearly sixty years to its credit, since no other country can produce a record equal to that of France.

---

[4] Tissandier, G. "Bibliographie Aéronautique" (1887), at page 40.

[5] Of which Dupuis Delcourt was described as the "founder."

THE CASE FOR THE REVIVAL OF THE WATER CHANNEL

BY N. S. NORWAY, B.A., A.F.R.AE.S.

Introduction

In surveying the mass of aerodynamic data presented to the designer of aeroplanes, one is struck by the fact that so much attention has been devoted to quantitative measurements upon bodies in a flow of air, so little to the equally important qualitative measurements. It is known that any body subjected to a flow of air is the means of creating eddies, yet relatively little attention has been given to the study of these eddies. Possibly the assumption has been that such eddies are of little importance since in the case of the aeroplane they are left behind the body that is causing them and so cannot exert a secondary effect upon it. In fact, an aeroplane in flight is the means of creating a vast number of whirls and eddies in the air, the majority of which are left harmlessly astern, some of which react upon its own structure. Of these whirls and eddies practically nothing is known. Indeed, they are so little considered that it comes almost as a surprise to a practical designer to see the vast disturbances that become evident behind an aeroplane "skywriting."

In the tractor aeroplane of normal type these eddies would not be expected to react very much upon the machine except in the region of the tail, and it is in the tail that the designer of tractor machines finds his greatest troubles. These troubles have been in evidence since the earliest days; the average designer has long ceased to worry very much about them. Rudder flutter, like the poor, is ever with us; we counter it by a preposterous factor of safety upon the fin post and the tail plane spars, and devote our ingenuity to minimising the shock upon the rudder bar. Again, the question of tail plane incidence proves a thorny one for the designer of high performance tractor biplanes. The tail incidence of a new machine is generally fixed in the light of data based on wind channel tests of models without propellers, yet it is a common experience for new machines to prove dangerously tail or nose heavy. The explanation usually advanced, disarming in its ingenuity, is that it is a "slipstream effect."

Again, in the testing of models in the wind channel it is frequently found that one combination of wing and fuselage will give a high value for maximum L/D, another combination of the same wing and fuselage will give a bad one. The phenomenon is classed as an "interference effect," and there exists no mechanism for deducing which arrangement of wing and fuselage will be the most efficient save a tedious and expensive process of trial and error. Finally, in the present state of wind channel development, there is no means of telling that the best arrangement found will be at all satisfactory when the slipstream from the propeller is present under full scale conditions.

It is not proposed to discuss in this paper the effect of the slipstream upon the drag of the fuselage. This effect has been very fully investigated and may probably be gauged with some accuracy in any given case. The slipstream, however, is capable of far more than merely increasing the drag of parts of the machine in it. It may, for example, exercise a marked effect upon the lift of the planes.

In the case of the single-engine tractor biplane this effect is not usually of any great importance. A very small proportion of the wing area lies in the slipstream and this is usually of small camber ratio. The case of the cantilever monoplane, however, is very different. Here the percentage of wing area lying

in the slipstream is far greater than in the biplane, and the area affected is of the "high lift" type. Owing to the rotation of the slipstream one side of the wing will be working at a great angle of incidence, the other side will be working at a correspondingly small angle, perhaps negative. It is evident that the lift will be very seriously affected.

Moreover, any aerofoil, or any body of other than ideal streamline shape, will set up eddies behind it when moving through still air. In general, the eddies produced by thin aerofoils appear to be less important than those produced by aerofoils of twelve per cent. camber or more. In the case of the cantilever monoplane, the thickest part of the wing is directly in front of the tail, with the result that when gliding with the engine throttled the tail may be subjected to violent eddies that are not present with the engine on, and the mean air speed over the tail be very widely different from the gliding speed of the machine. This has actually been recorded. When to this effect is added the effect of a turbulent and rotating slipstream blowing over the thickest portion of the wing, it will readily be seen that the tail conditions in flight may differ so widely from wind channel conditions that previous determinations of stability and control may prove entirely misleading.

None of these particular troubles are very apparent in thin wing biplanes of conventional proportions, and the effect of concentrating on this type of machine has been to obviate the necessity for research into these eddies. Now, however, aeroplane design seems to have reached a point where such research is necessary.

And here an unwelcome digression must be made to emphasise the importance of this subject. In the past year two cantilever monoplanes have been built in England and flown for the first time. Both crashed upon their trial flights—one fatally. In one case at least it seems certain that lack of control was the cause of the disaster. These accidents are referred to as evidence that the investigation of these eddies may be no academic problem but a matter of the utmost importance for designers.

It appears that there are three ways in which the breed of aeroplanes may be improved:—

By the use of Handley Page slots, or similar devices.

By the development of the cantilever monoplane, with its practicable loading of 17 lbs./sq. ft.

By a careful "cleaning up" of existing types.

For complete development along these lines a study of the eddies and air flow about the machine is essential in each case. To design a slotted aerofoil with accuracy means that the path of each particle of the fluid in which it is working must be followed on its course. In applying the slotted aerofoil to a machine some study of tail control is desirable in the interests of safety. To make full use of the slots (according to data published up to date) it will be necessary to alter the incidence of the wing upon the machine by some thirty degrees, at the same time opening five slots in it. The effect of such an alteration upon the eddies about the tail of a single-engined tractor machine must, for the present, be left to the imagination.

The case of the cantilever monoplane has been referred to above. The third direction in which improvement may be effected lies in the "cleaning up" of existing types to present the least resistance to air which, at any rate over the fuselage, is moving in a turbulent rotation. Here again a study of air flow and eddies under the conditions of service is of the greatest importance. It is possible that in view of the rotation of the slip the aerodynamically perfect aeroplane would not be symmetrical, but whether such high ideals will ever be attained in practice is another matter.

It is the object of this paper to suggest a means whereby information on these points may be acquired.

The Water Channel

In the very early days of the Royal Aircraft Factory a considerable amount of research was carried out with the aid of small water channels. For the most part these were used to determine visually the eddies formed by a moving fluid around bodies such as strut sections or airship forms. The method generally employed was to smear the body with condensed milk before inserting it into the stream, when as the milk came off in the water the eddies became visible. Another method was to inject into the stream some distance above the model a thin streak of some coloured liquid which was allowed to flow downstream and play about the model, thus disclosing the eddies. A later evolution was to mount the model on a balance and proceed to the measurement of forces. This led immediately to the wind channel. With the advent of the wind channel the water channel was discarded as a means of aeroplane research, and has never been revived.

Descriptions of these channels will be found in R. & M.'s 17 and 31.

As the matter has been largely forgotten it may be of interest to re-state very briefly the theory of dynamic similarity upon which the use of a water channel or of a compressed air channel is based. From the chapter on Dynamic Similarity in Professor Bairstow's volume, the following statement of the law is extracted:—"Two motions of viscous fluids will be similar if the size of the obstacle and its velocity are so related to the viscosity that VLe/μ is constant." In this relation μ represents the coefficient of viscosity.

For water the value of e/μ is about thirteen times that for air. It follows that when a certain object is placed in a stream of air of a certain velocity and produces eddies, the same eddies will be produced when the object is placed in a stream of water of one-thirteenth the velocity. Alternatively the same eddies will be produced when a quarter-scale model of the object is placed in a stream of water of four-thirteenths the velocity.

A striking example of this similarity of the eddies in air and water was made in the small water channel of the Royal Aircraft Factory, and may be found in R. & M. 58.

These considerations, together with the growing importance of the eddies about aeroplanes, have led to the reconsideration of the water channel as a means of model research, in much the same manner as model aeroplanes are now tested in a wind channel. It may be as well first of all to indicate the type of channel proposed and then to proceed to an examination of the advantages or otherwise of the water channel.

The channel will be an open trough of water, of section seven feet square. For obvious reasons it will be of the circulating type, oval in plan form, of uniform section throughout. On one side, in a straight portion, will be the working section, and this straight portion should not be less than twenty feet long. At a suitable distance downstream from the model will be mounted a large propeller actuated by a horizontal shaft passing through the wall of the channel. Disposed about the working section will be such honeycombs as are needed to provide a smooth flow.

It is estimated that in such a channel a hundred horse-power will give a speed of between forty and sixty feet per second. Such speeds are of little use unless the flow is reasonably smooth to permit the unbiassed examination of eddies. In a channel of the dimensions stated above the working section will be some fifty feet downstream from the propeller. Under these circumstances it is

assumed that it will be possible to secure a smooth flow through the working section of some thirty feet per second.

Given such a channel, what can be done with it?

The first consideration is the size of the model that can reasonably be put in it. In this channel eddies are to be measured, not forces. The method of experiment will be as it was in the earlier channels; a small streak of coloured liquid will be inserted upstream and allowed to flow down and play about the model. Under these circumstances the interference of the channel walls will not be of any great importance for two reasons:—

Any modification of the eddies due to interference of the channel walls should show clearly in their formation.

The part of the model under examination may be arranged to be in the centre of the channel.

In nine cases out of ten this part under examination will consist of the fuselage, propeller, central portion of the wings, and the tail unit. That is to say, in the examination of the eddies about a double-bay tractor biplane, the wings may be truncated at the inner bay and the remainder placed in the channel for test.

Under these circumstances it would not be disproportionate to place a quarter-scale model of a two-seater machine in the water channel, or a third-scale model of a very small machine such as a light aeroplane.

In the latter case the full-scale eddies will be reproduced in water at three-thirteenths of the full-scale speed. That is to say, suppose the climbing speed of the light aeroplane to be forty-five miles an hour, this condition would be reproduced in the water channel at a speed of fifteen feet/second. The full speed of seventy miles an hour would be reproduced by a water speed of twenty-five feet/second.

In the case of the eddies about this light aeroplane, then, it seems that complete dynamic similarity with full scale can be achieved.

Propeller Conditions

The propeller of the model will be operated externally by gearing. Several methods will suggest themselves; the one that may prove most suitable is that of actuating the propeller of a tractor model by a long shaft running down the centre of the fuselage to a point behind the model where it passes through a bevel gear to the power plant.

The theory governing the rate of revolution of the propeller is simple. In the general form it may be stated as follows. Consider a water speed of $1/n$ of full scale. The scale of the model is then $n/13$ for dynamic similarity. If the model propeller were to run at full-scale revolutions, an element of the blade would run at $n/13$ of the full-scale speed of the element. But to retain the same pitch angles on the model propeller, we want this element to run at $1/n$ of its full-scale speed. Therefore the rate of revolution must be multiplied by $13/n^2$.

In the case of the one-third scale model light aeroplane instanced above, this means that the propeller must run at 69 per cent. of the full-scale revolutions.

Eddies in the slipstream will then be formed at 69 per cent. of the periodicity proper to full scale. To reproduce full-scale conditions most accurately it is desirable to have the eddies formed at full-scale periodicity. That is to say, the propeller should run at full-scale revolutions. To effect this with a scale model propeller it is evident that both model dimensions and water speed must be reduced from full scale in the ratio of $1/\sqrt{13}$, or $1/3.61$.

To summarise the above, we can have a 1/3.61 scale model in a stream of water of 1/3.61 full-scale velocity, with the model propeller running at full-scale revolutions. The eddies formed in the slipstream will be in all respects similar to those occurring in flight, and will be formed at the periodicity proper to flight.

In this case an air speed of seventy miles an hour will be reproduced by a water speed of 28.5 feet/second.

Practical Considerations

From the above it will be seen that it should be possible to provide a direct link of dynamic similarity between the water channel and full scale, in the case of the light aeroplane. How far up the range of VL it is possible to go is dependent on the size of the water channel and the speed that can be attained in it, though it is doubtful if dynamic similarity could ever be attained in the case of very large or very fast machines. The direct link with full scale afforded in the case of the light aeroplane, however, should make it easy to investigate the change in flow due to the reduction of the VL ratio. Such data should be capable of application in the case of large or fast machines, exterpolating up the range of VL.

It will be seen that in this paper the water channel is not put forward in the form of an instrument of precision, but rather as an aid to the practical designer of aeroplanes. Since aeroplanes are designed to be sold, and to be sold as cheaply as possible, it will be of interest to investigate the construction of such a channel in relation to its cost.

The first consideration is that, unlike the wind channel, great accuracy is not necessary. The water speed should be capable of regulation to within about five per cent. of that desired; the same order of accuracy will be sufficient for the propeller speed of the model. There is no balance to be provided.

The channel will be oval in plan, about thirty-five by twenty-five feet overall dimensions, of seven feet square section, constructed of wood made watertight. No special finish will be given to the interior, which will be planed and painted white. A water supply will be provided, and a drain.

The channel will contain about ninety tons of water.

For the power unit, about a hundred horse-power will be required. An inexpensive and suitable installation would be an obsolete aero engine such as the 160 h.p. Beardmore, fitted with a flywheel and converted to run on coal gas. Such a power plant in practice gave no trouble in over a thousand hours of workshop use. In defence of such a makeshift arrangement, it is repeated that this channel will be of most use to the practical designer. An electrical power plant would be preferable—and considerably more expensive.

A separate power plant and gearing must be provided for driving the propeller of the model. It would probably be convenient for this to be electric, and of about thirty horse-power.

A channel of the above description could probably be constructed for the sum of six hundred pounds, including both power plants and gearing, together with the cost of design, not including the building in which it is erected or the cost of the models. Such a channel, if not cheap, would be at any rate very much cheaper than a wind channel and likely to lead to more information of immediate practical use in the design of aeroplanes.

Whether the information acquired would justify the cost is a question for each individual designer to settle for himself.

Conclusion

The case for the water channel would hardly be complete without reference to the researches for which it is specially adapted

The first point and possibly the most important is the problem of securing a smooth flow over the tail. With any given model in the channel with the propeller running, it should be possible to observe the entire system of eddies about the fuselage and tail. The form of the fuselage may then be moulded with wax till the eddies are reduced to a minimum and the tail is relatively free. It is suggested that the form of fuselage which gives this condition would prove to be the most efficient in flight. It is possible that a two-bladed propeller would produce a different system of eddies to a four-bladed.

Struts and wires meeting an aerofoil are known to disturb the flow over it and to affect its lift, but to what extent is still very little known. It would be of some value to be able to see the eddies and disturbances formed. It is becoming common practice to support monoplane wings by oblique struts running to the fuselage either above or below the aerofoil, and at a relatively small angle to it. A certain amount of lift is lost by interference; to what extent is this practice worth while? A visual study of the interference would be of service here.

In many types of aerofoil design, such as slotted aerofoils and aerofoils followed by a detached flap for use as aileron, a study of the flow should be of considerable service.

The investigation of the flow through propellers, of inflow and of blade interference, should benefit by research in the water channel. It is perhaps hardly necessary to add that the vortex theory of aerofoils should benefit by such research.

It is, however, to the practical designer that this paper is chiefly addressed. In the aeroplane of to-day there are many points on which we have no knowledge —far too many. We don't know what is actually happening to the air about the machine; we possess no means of telling whether the air flow about a given machine is of a possibly dangerous type. Safety lies in knowledge; until we know in detail what is happening to every part of the machine, we shall always be liable to disaster in the air, sudden weakness of control, inexplicable failure of the structure.

It is the belief of the author that many such disasters could be avoided by a study of the flow about the machine, and that the water channel is the most suitable means of carrying out this study.